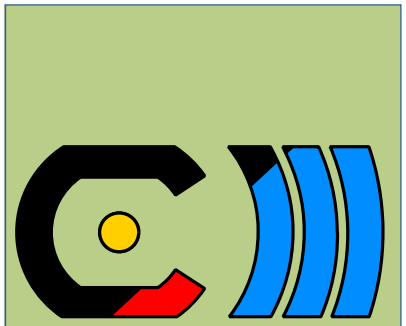
# ДВА ПОДХОДА К ВОПРОСУ О ДИБАРИОНАХ

Е. ДОРОШКЕВИЧ, ИЯИ РАН



02.04.2024

# дибарионы

## эксперименты

- реакции $pN \to d\pi\pi$

  $pn \to NN\pi\pi$

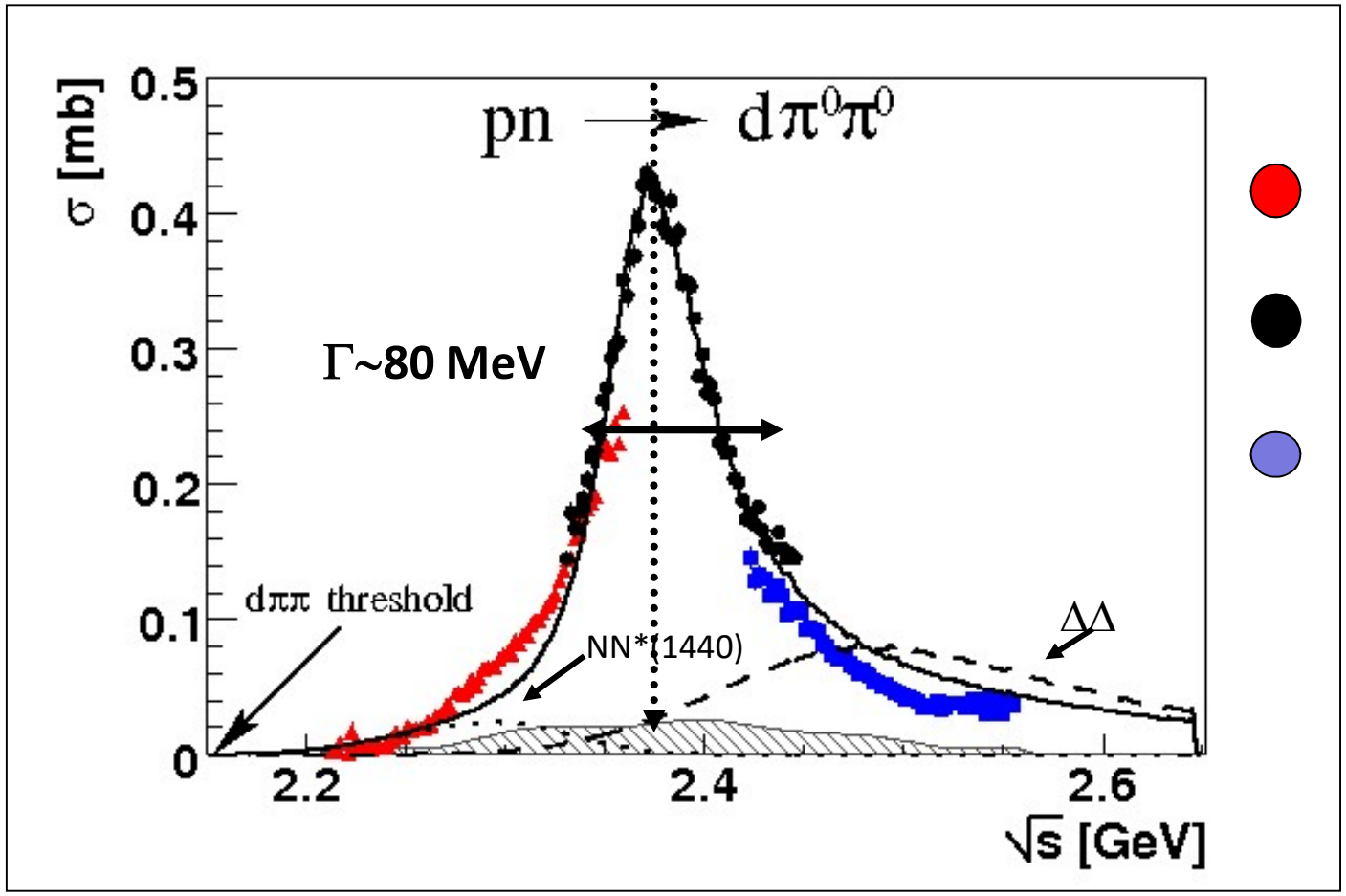
- реакции NN

## теоретическое описание

- масса. ширина
- спин, изоспин
- мультиплеты

# ПОЛНОЕ СЕЧЕНИЕ $pn \to d\pi^0\pi^0$

**дибарион d* в эксперименте WASA-at-COSY**



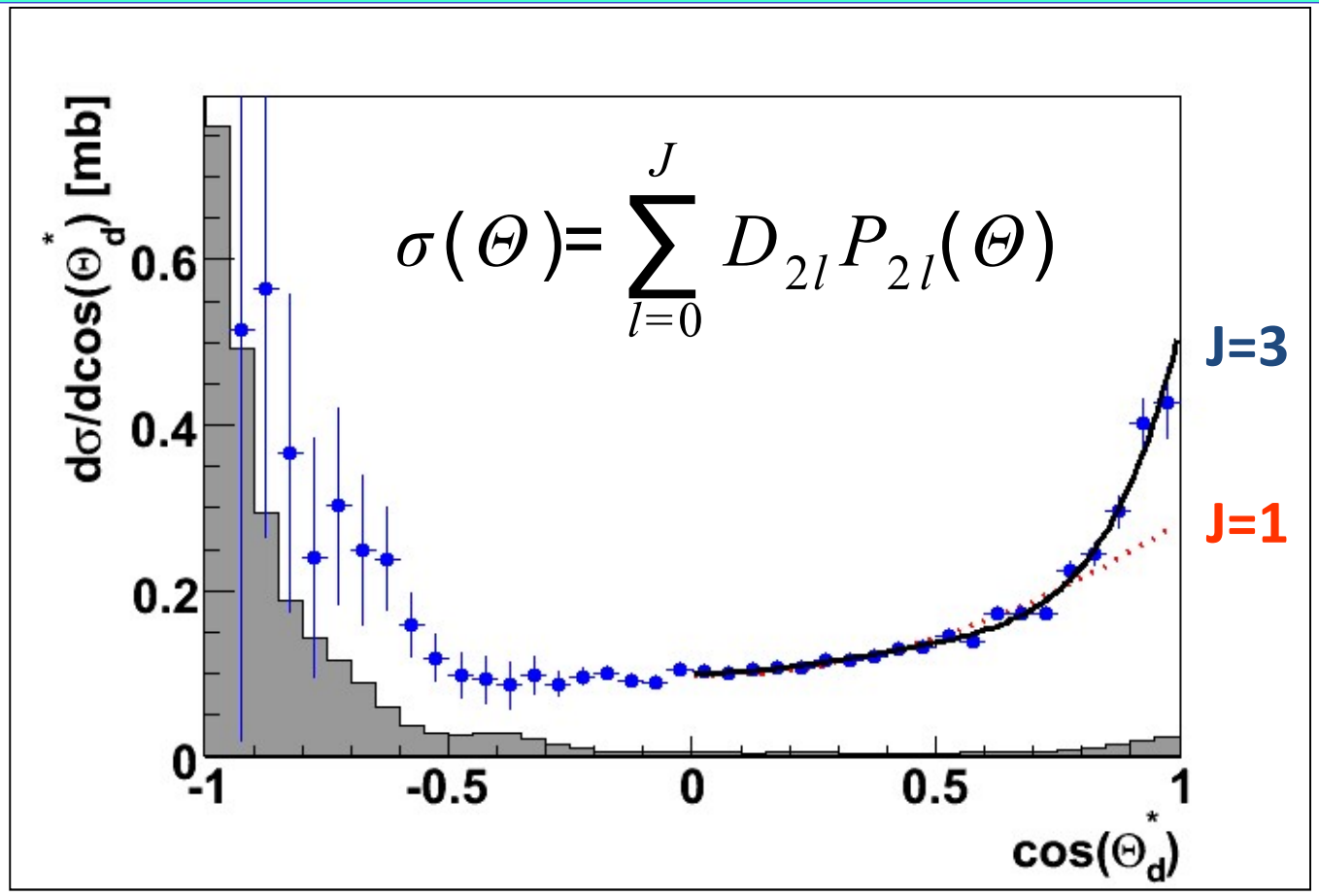

$T_p$ =1.0 GeV

$T_p$ =1.2 GeV

$T_p$ =1.4 GeV

*P. Adlarson et. al Phys. Rev. Lett. 106:242302, 2011*

# УГЛОВОЕ РАСПРЕДЕЛЕНИЕ d В С.Ц.М.




*P. Adlarson et. al*
*Phys. Rev. Lett.*
*106:242302, 2011*

# Предсказания

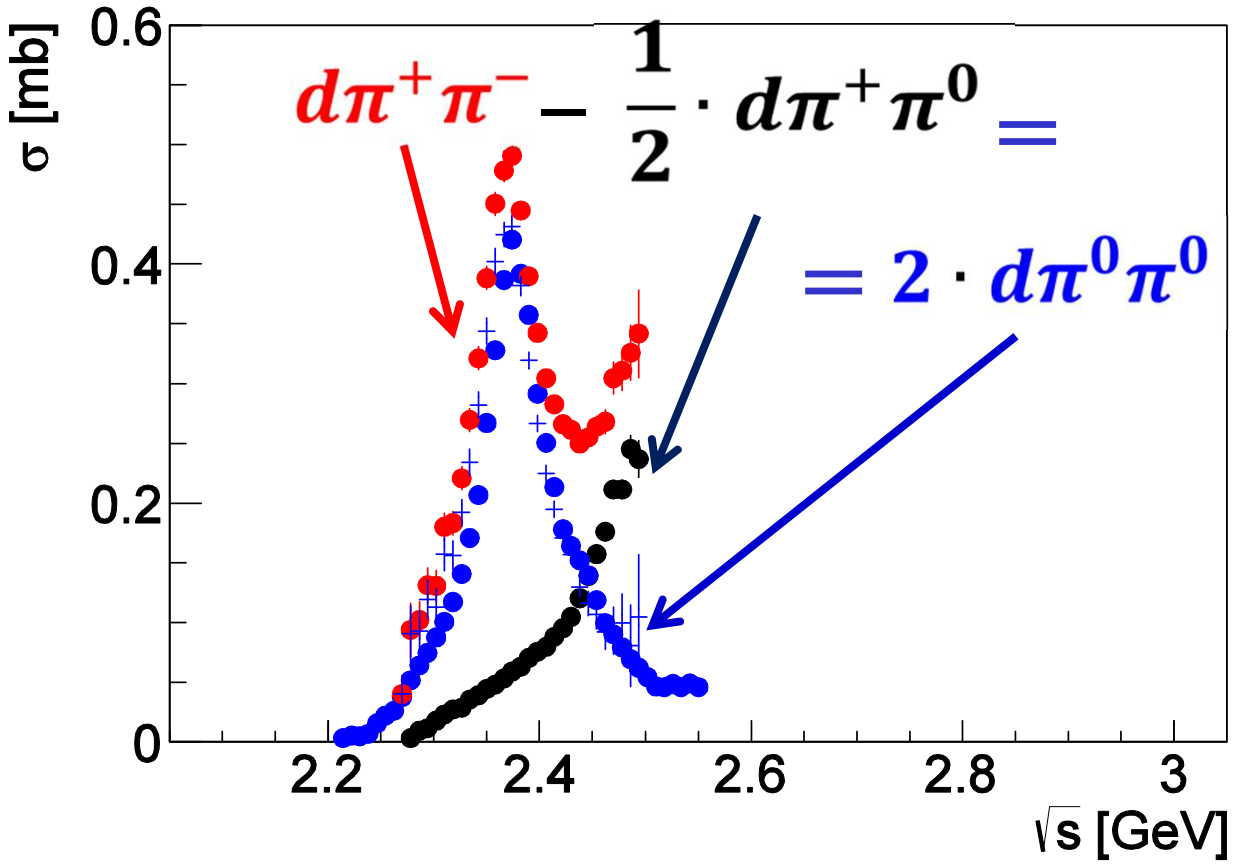
F. J. Dyson, N-H Xuong PRL. 13(1964) 815

| I | J | Theo [MeV] | Exp. [MeV] |
|---|---|---|---|
| 0 | 1 | 1876 | **1876** |
| 1 | 0 | 1876 | 1878 |
| 1 | 2 | 2160 | 2160 |
| 2 | 1 | 2160 | 2160 |
| 0 | 3 | 2350 | **2380** |
| 3 | 0 | 2350 | 2464 |

# ФОРМУЛА ДЛЯ ИЗОСПИНОВ

$$\sigma[pn \to d\pi^+\pi^-] = \underbrace{\frac{1}{2}\sigma[pp \to d\pi^+\pi^0]}_{I=1} + \underbrace{2\sigma[pn \to d\pi^0\pi^0]}_{I=0}$$

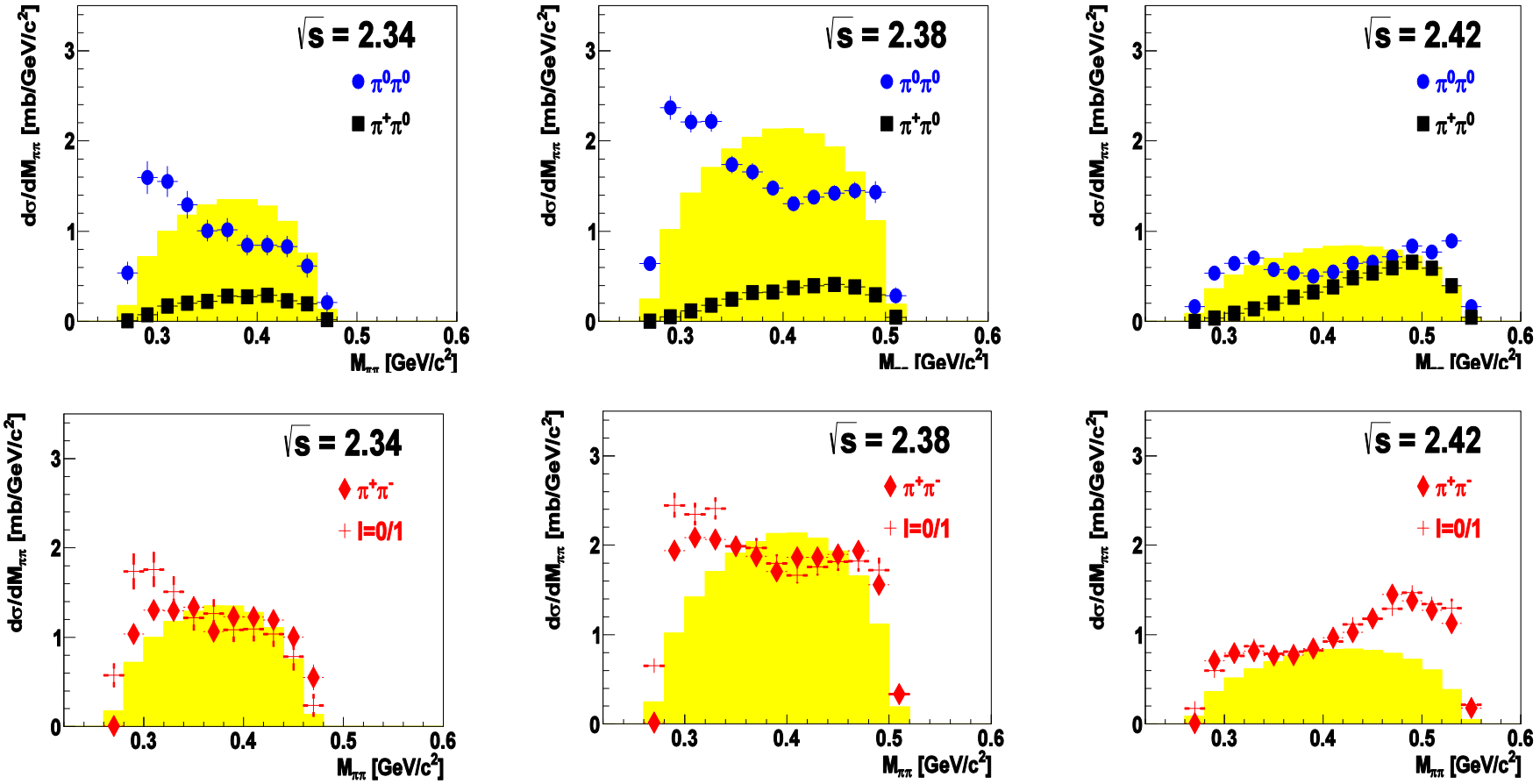
# ПОЛНЫЕ СЕЧЕНИЯ pd → dππ+$N_{spect}$




*P. Adlarson et. al Phys. Lett. B721 (2013) 229*

# $M_{\pi\pi}$ спектры для 40 MeV бинов по $\sqrt{s}$

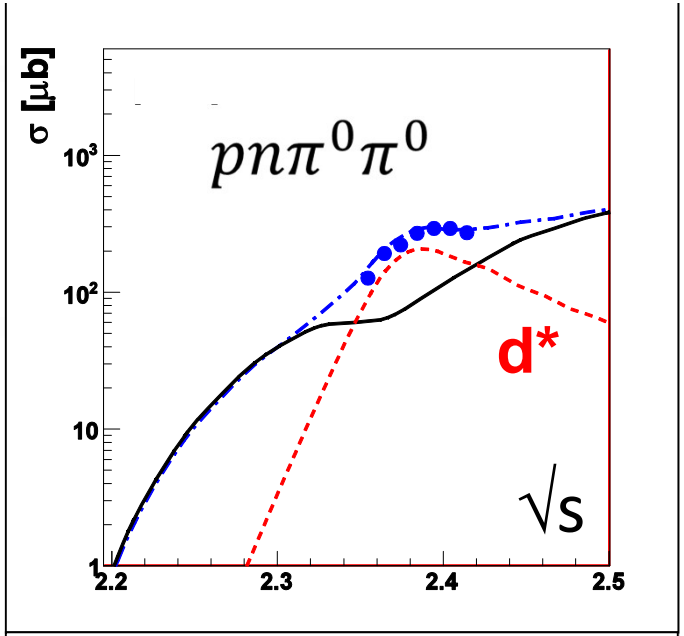
$$\sigma[pn \to d\pi^+\pi^-] = 2\,\sigma[pn \to d\pi^0\pi^0] + \tfrac{1}{2}\sigma[pp \to d\pi^+\pi^0]$$

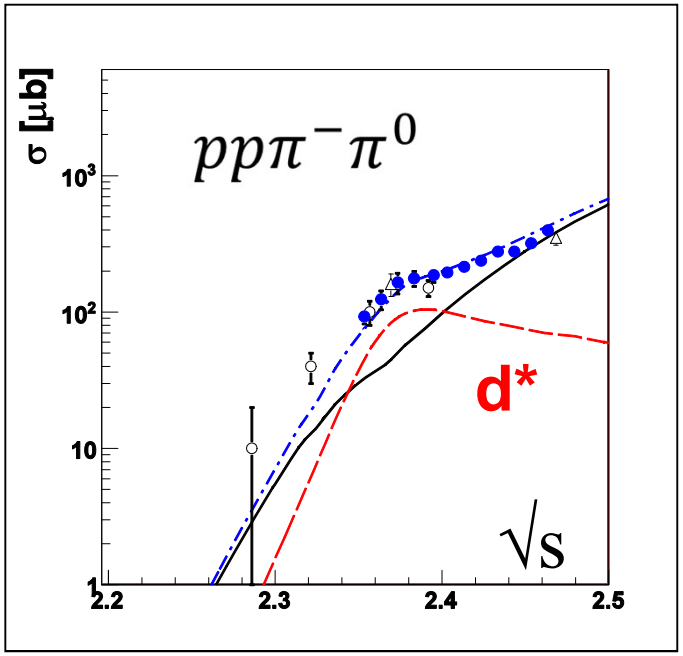


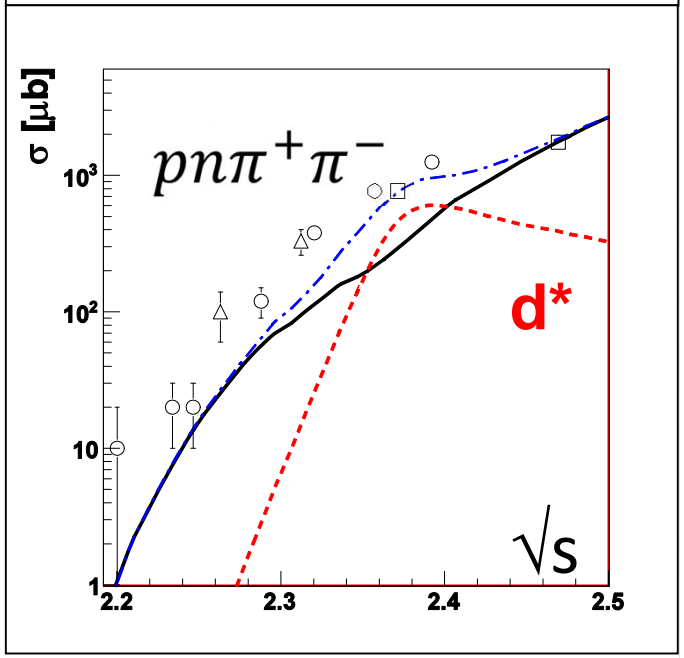
# реакции $pn \rightarrow NN\pi\pi$

PRC 88 (2013)

$\sigma_d / \sigma(NN\pi\pi) \sim 170\mu b/40mb$



# квазиупругое $\vec{n}p$ рассеяние

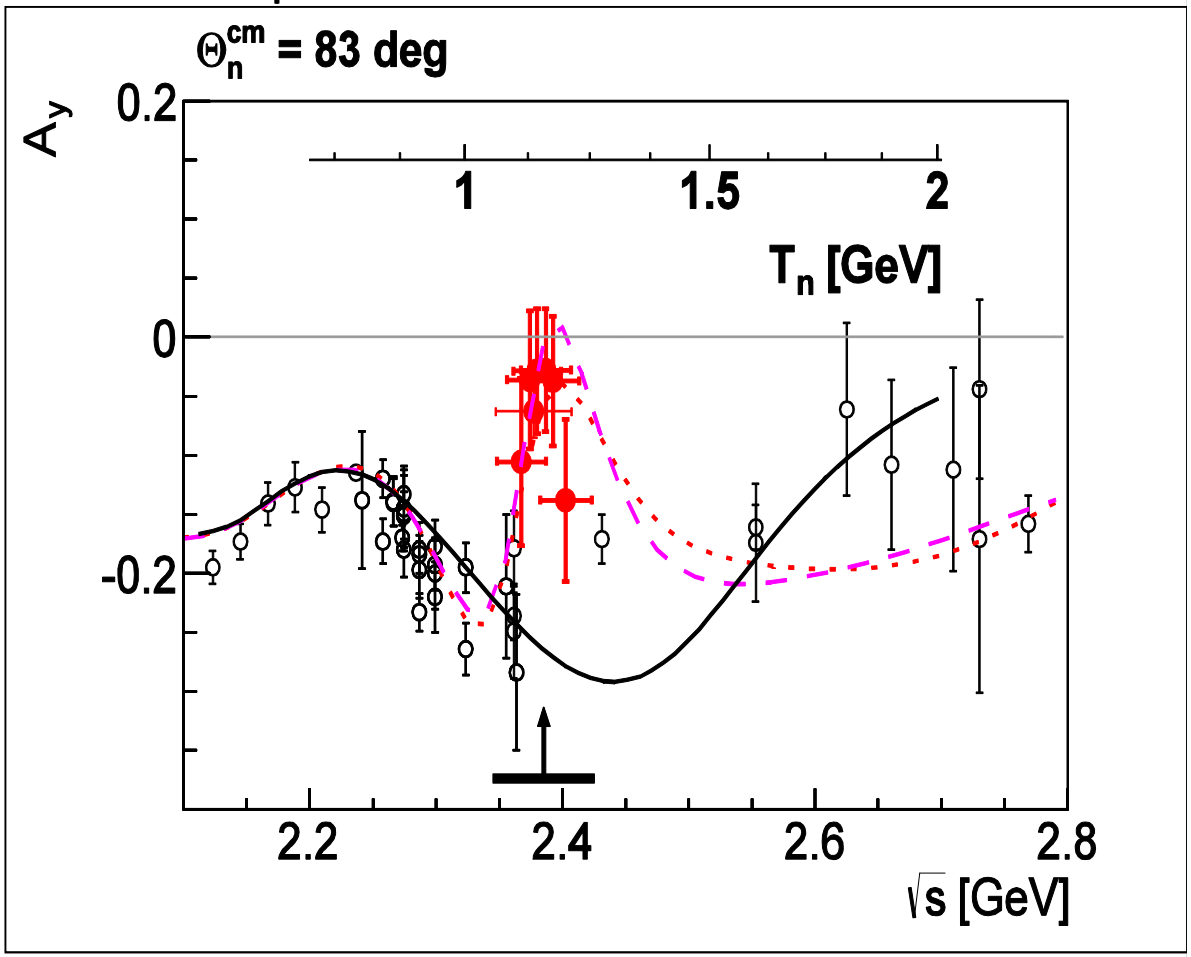
Рассеяние поляризованных d на p

T=2.27GeV

$\vec{d}\,p \rightarrow np+p_{spect}$

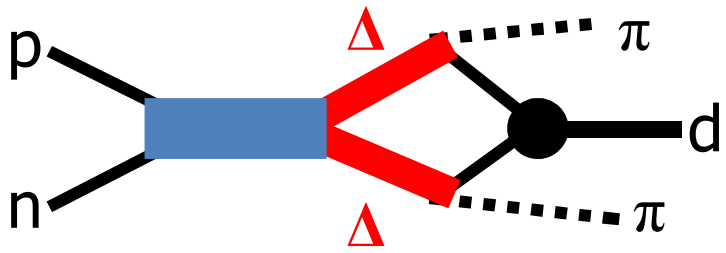
диапазон энергий, где вклад $d^*$ наибольший

PRL 112 (2014) 202301
arXiv:1408.4928



# ХАРАКТЕРИСТИКИ ДИБАРИОНА d*(2380)

$$pn \rightarrow \textbf{dibaryon} \rightarrow \Delta\Delta \rightarrow d\pi^0\pi^0$$




**$I(J^P) = 0(3^+)$**

$$M_{d^*} = 2380 \pm 10\ МэВ \approx 2M_{\Delta} - 90\ МэВ$$

$$\Gamma_{d^*} = 80 \pm 10\ МэВ << \Gamma_{\Delta} \approx 240\ МэВ$$

# КАНАЛЫ РЕАКЦИЙ

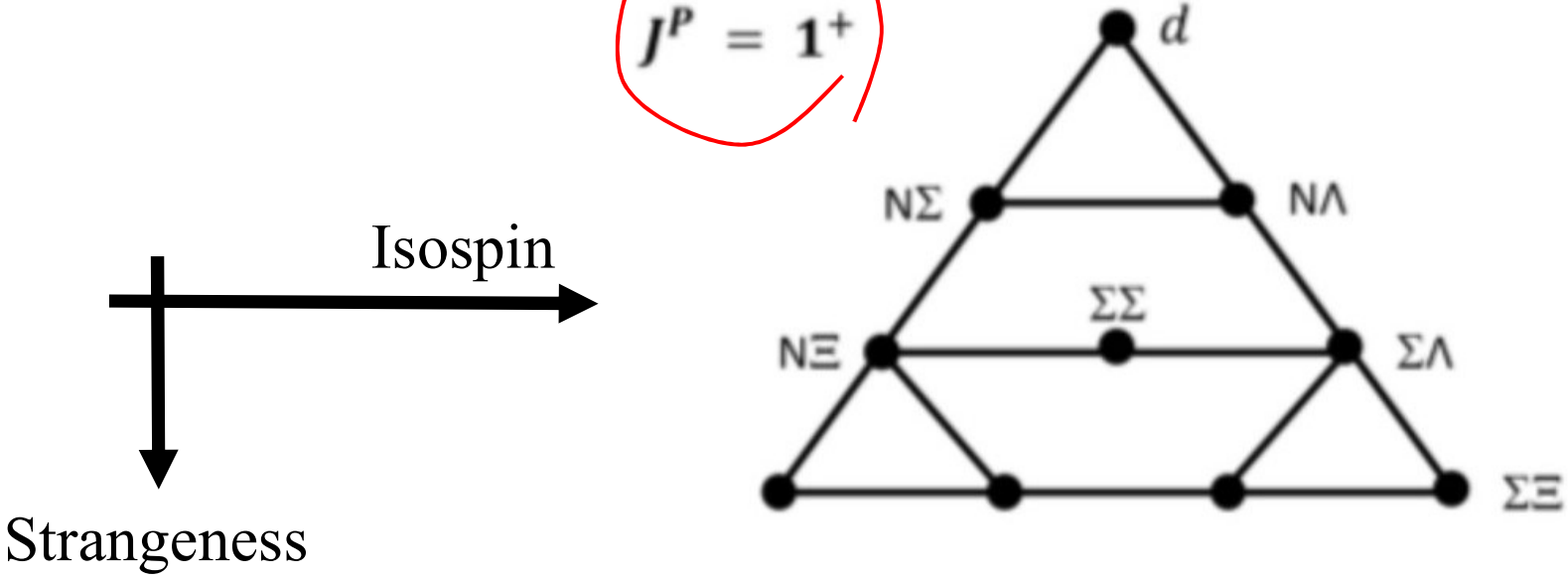
| Channel | Publications |
|---|---|
| $\mathbf{d\pi^0\pi^0}$ | M. Bashkanov et. al Phys.Rev.Lett. 102 (2009) 052301<br>P. Adlarson et. al Phys. Rev. Lett. 106:242302, 2011<br>P. Adlarson et. al Phys.Lett. B721 (2013) 229-236 |
| $\mathbf{d\,\pi^+\pi^-}$ | P. Adlarson et. al Phys.Lett. B721 (2013) 229-236 |
| $\mathbf{pp\pi^0\pi^-}$ | P. Adlarson et. al Phys. Rev. C 88, 055208 |
| $\mathbf{np\pi^0\pi^0}$ | arXiv:1409.2659 |
| **np** | A. Pricking, M. Bashkanov, H. Clement. arXiv:1310.5532<br>P. Adlarson et al. Phys. Rev. Lett. **112**, 202301, (2014)<br>P. Adlarson et al. Phys. Rev. C **90**, 035204 , (2014) |
| **pn** $\mathbf{e^+e^-}$ | M. Bashkanov, H. Clement, Eur.Phys.J. A50 (2014) 107 |

H.Clement
On the History of Dibaryons and their Final Observation
arXiv: 1609.05591.pdf

# SU(3) ДЕКУПЛЕТ ПАР БАРИОНОВ

M. Bashkanov, D. P. Watts, G. Clash, M.Mocanu, M. Nicol
arXiv:2308.07066
Dibaryons and where to find them

$J^P = 1^+$



# THE ANTIDECUPLET OF STATES BUILT ON THE SIX-QUARK

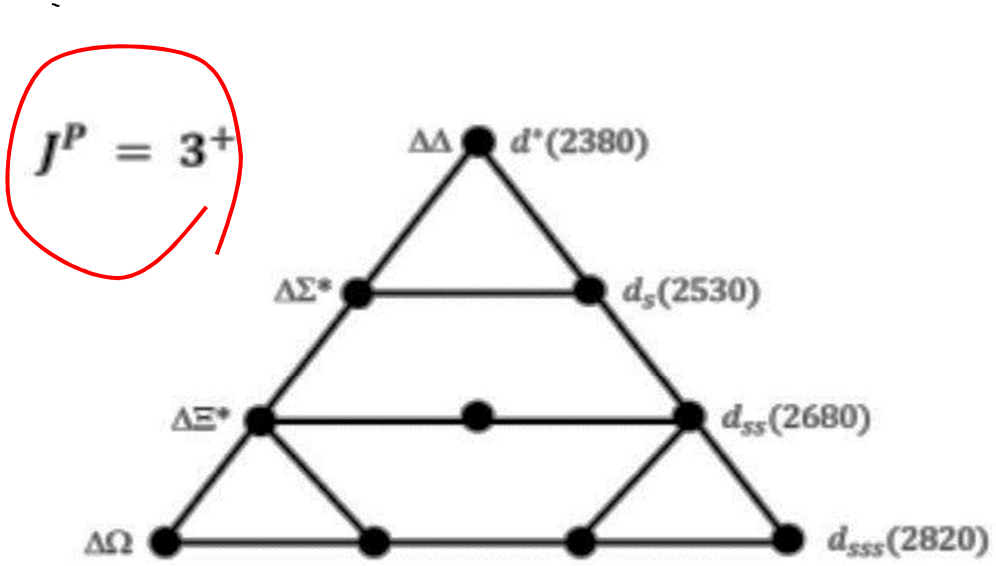
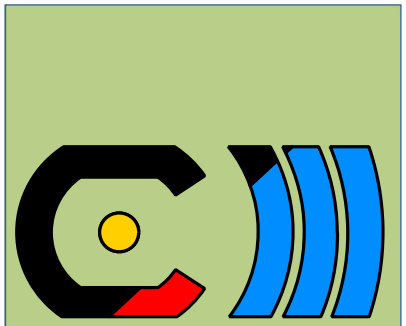



Figure 3: $d^*(2380)$ multiplet

# СПАСИБО ЗА ВНИМАНИЕ!

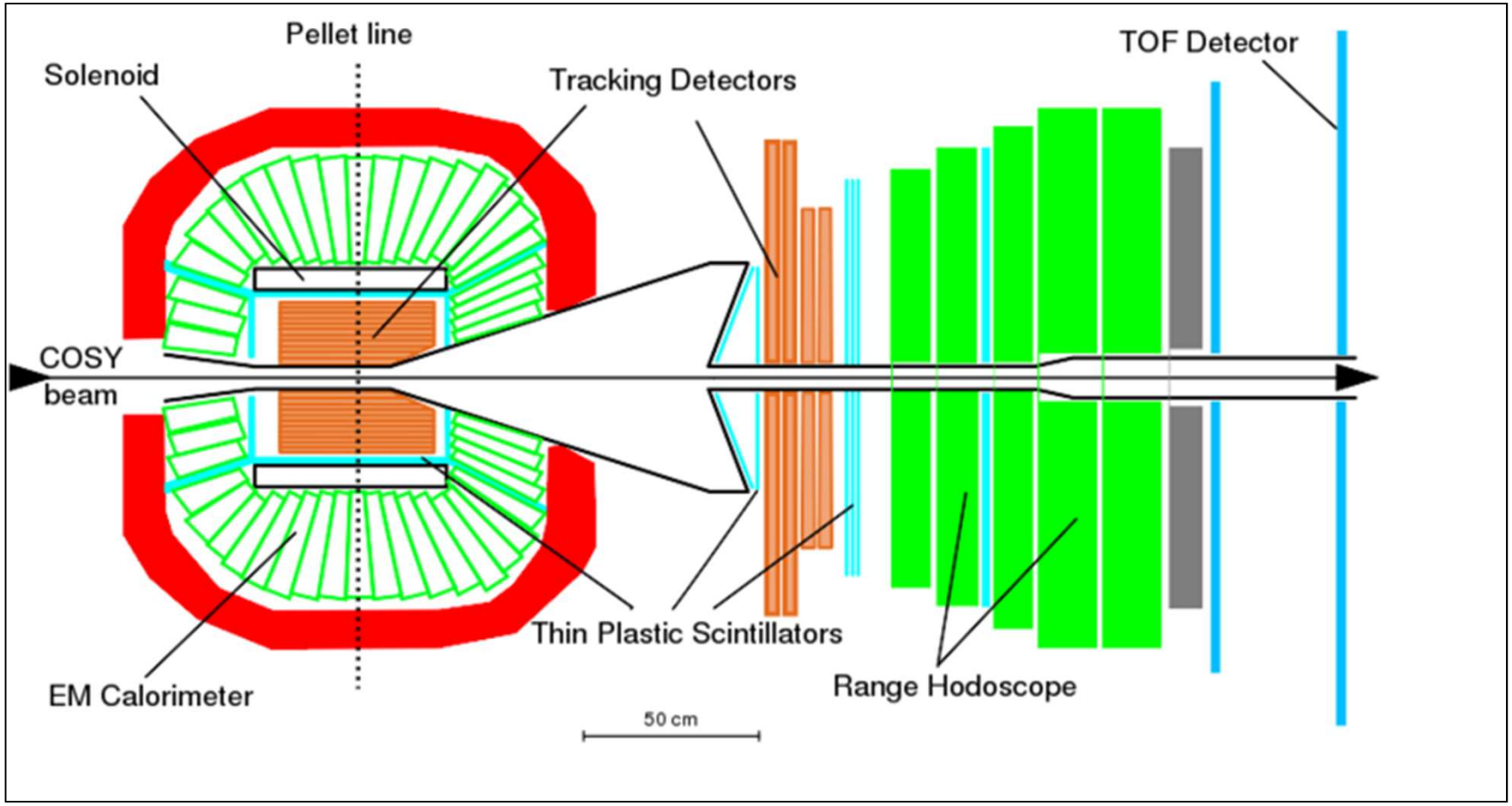
## ДВА ПОДХОДА К ВОПРОСУ О ДИБАРИОНАХ

Е. ДОРОШКЕВИЧ, ИЯИ РАН



02.04.2024

# WASA DETECTOR AT COSY



# ОСНОВНЫЕ РЕЗУЛЬТАТЫ

- Измерение зависимости сечений рассеяния *pn* от начальной энергии.
- Измерение полных сечений реакций

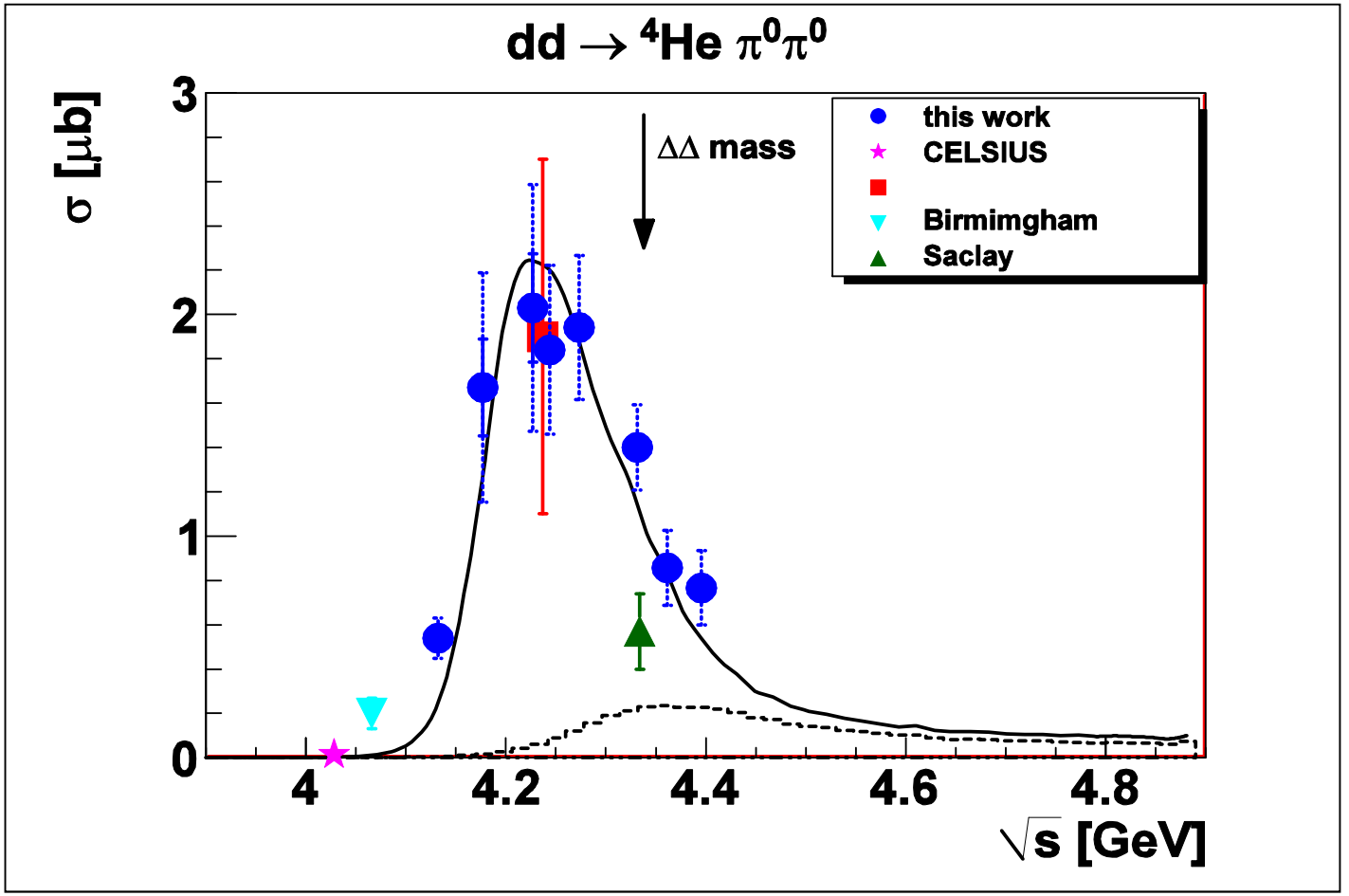
  $pn \rightarrow d\pi^0\pi^0$, $pn \rightarrow d\pi^+\pi^-$, $pp \rightarrow d\pi^+\pi^0$ . $pd \rightarrow d\pi^-\pi^0 + p_{spect}$

- Мультиплеты дибарионов

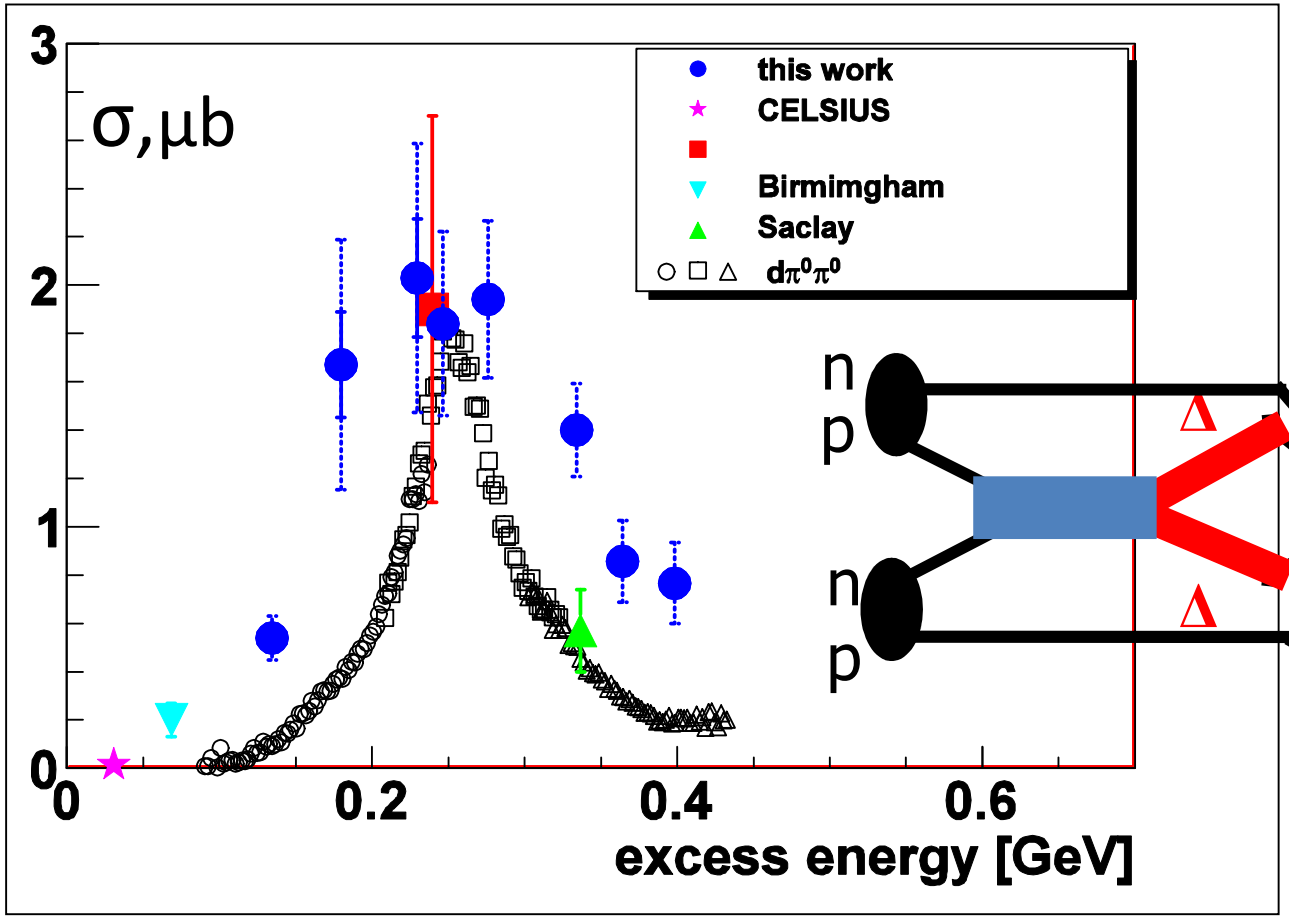
# ТЕОРЕТИЧЕСКИЕ ПРЕДСКАЗАНИЯ СОСТОЯНИЙ
## $I(J^P) = 0(3^+)$

- F. J. Dyson, N-H Xuong PRL. 13(1964) 815
- T. Goldman, et al, PRC 39, 1889 (1989)
  - "d*", "inevitable dibaryon"
- M. Bashkanov, D. P. Watts, G. Clash, M.Mocanu, M. Nicol //arXiv:2308.07066 Dibaryons and where to find them
- A. Gal, H. Garcilazo PRL 111 (2013) 172301
  - Faddeev-Yakubovsky calculations
- H. Huang, J. Ping, F. Wang, PRC 89, 034001 (2014)
  - Quark model
- F. Huang, Z.Y. Zhang, P.N. Shen, W.L. Wang arXiv:1408.0458
  - RGM, "hexaquark-dominated exotic state"

# TOTAL CROSS SECTION dd → $^4$He$\pi^0\pi^0$

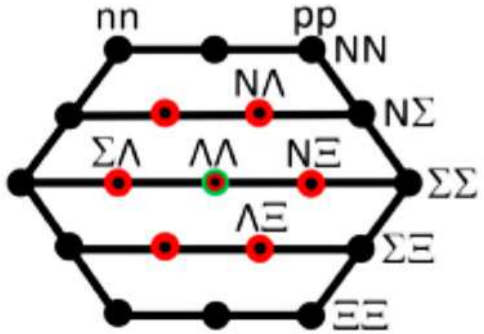


# TOTAL CROSS SECTION dd → $^4$He$\pi^0\pi^0$




*P. Adlarson et. al., Phys.Rev. C86 (2012) 032201*

# THE 27-PLET 8 ⊕ 8 OF SPIN 0 STATES




| S | Max Isospin | Med Isospin | Min Isospin | Mass [MeV] |
|---|---|---|---|---|
| 0 | NN | | | NN(1876) |
| -1 | NΣ | $\frac{1}{\sqrt{10}}(3N\Lambda - N\Sigma)$ | | NΣ(2127) NΛ(2054) |
| -2 | ΣΣ | $\frac{1}{\sqrt{10}}(\sqrt{6}\Sigma\Lambda + 2N\Xi)$ | $\frac{1}{\sqrt{10}}(\frac{3\sqrt{3}}{2}\Lambda\Lambda - \sqrt{3}N\Xi - \frac{1}{2}\Sigma\Sigma)$ | ΣΣ(2378)ΣΛ(2305)NΞ(2253)ΛΛ(2232) |
| -3 | ΣΞ | $\frac{1}{\sqrt{10}}(3\Lambda\Xi - \Sigma\Xi)$ | | ΣΞ(2504)ΛΞ(2431) |
| -4 | ΞΞ | | | ΞΞ(2630) |

# Публикации

Probing the internal structures of pΩ and ΩΩ with their production at the LHC
Jie Pu, Kai-Jia Sun, Chun-Wang Ma, Lie-Wen Chen//arXiv:2402.04185

Production of the ΞN dibaryon as a weakly bound system in pp collisions
Tian-Chen Wu, Atsushi Hosaka, Li-Sheng Geng//arXiv:2311.02022

First study of reaction Ξ0n→Ξ−p using Ξ0-nucleus scattering at an electron-positron collider
BESIII Collaboration, M. Ablikim et.al.//arXiv:2304.13921